Monte Carlo localisation using particle filter

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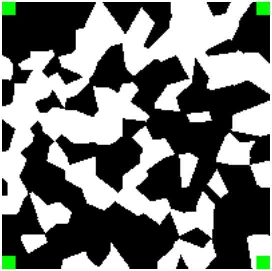
Problem formulation

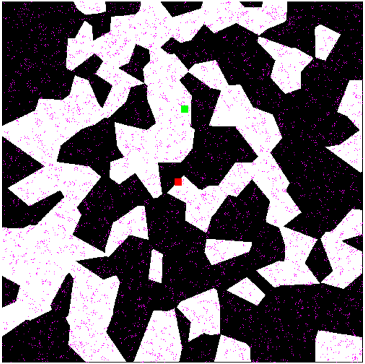
Robot localisation on known map

- map, $\hat{o} = m(\hat{x}, \hat{y}) = m(\hat{r})$
- position change, $dr = (dx, dy) + noise$
- observation, $o(x, y) = o(r)$



Particle filter - initialization

Generate tons of random hypothesis -> particles
Particle : **position** + **weight**



Particle filter - algorithm

```
Data: map, dr, observation
Result: position R
initialization
$P_r$ = random particles positions
$P_w$ = only fist time init particles weights to zero
R = 0
MoveParticles($P_r$, dr)
$P_w$ = ComputeWeights(observation, $map(P_r)$, $P_w$)
$P_w$ = NormaliseWeights($P_w$)
for i from 0 to particles_count do
    R = R + $P_w(i)P_r(i)$
end
$P_r$ = Resample($P_w$, $P_r$)
```

Complexity analysis - naive implementation

```
Data: map, dr, observation
Result: position R
initialization
$P_r$ = random particles positions
$P_w$ = only fist time init particles weights to zero
R = 0
MoveParticles($P_r$, dr) //$O(N)$
$P_w$ = ComputeWeights(observation, $map(P_r)$, $P_w$) //$O(NM)$
$P_w$ = NormaliseWeights($P_w$) //$O(N)$
//$O(N)$
for $i$ from 0 to particles_count do
    R = R + $P_w(i)P_r(i)$
end
$P_r$ = Resample($P_w$, $P_r$) //$O(N^2)$
```

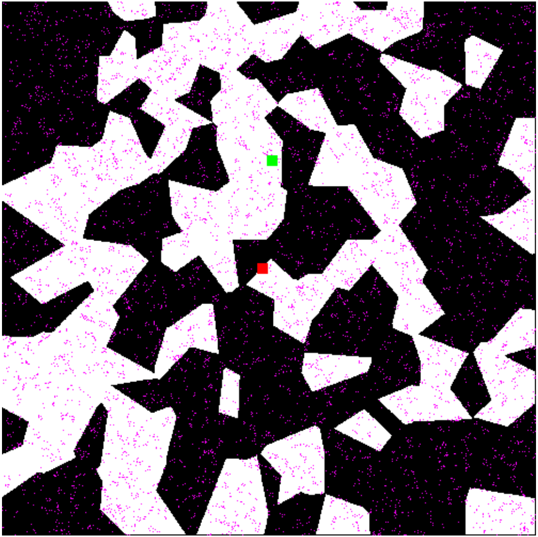
$total = O(3N + NM + N^2)$

Complexity analysis - optimal? implementation

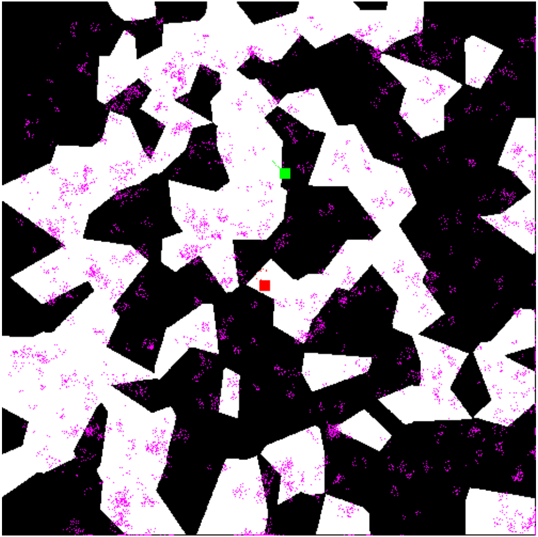
```
Data: map, dr, observation
Result: position R
initialization
$P_r$ = random particles positions
$P_w$ = only fist time init particles weights to zero
R = 0
MoveParticles($P_r$, dr) //$O(N)$
$P_w$ = ComputeWeights(observation, $map(P_r)$, $P_w$)
//$O(Nlog_2(M))$
$P_w$ = NormaliseWeights($P_w$) //$O(N)$
//$O(N)$
for i from 0 to particles_count do
    R = R + $P_w(i)P_r(i)$
end
$P_r$ = Resample($P_w$, $P_r$) //$O(Nlog_2(N))$
```

$$total = O(3N + Nlog_2(M) + Nlog_2(N))$$

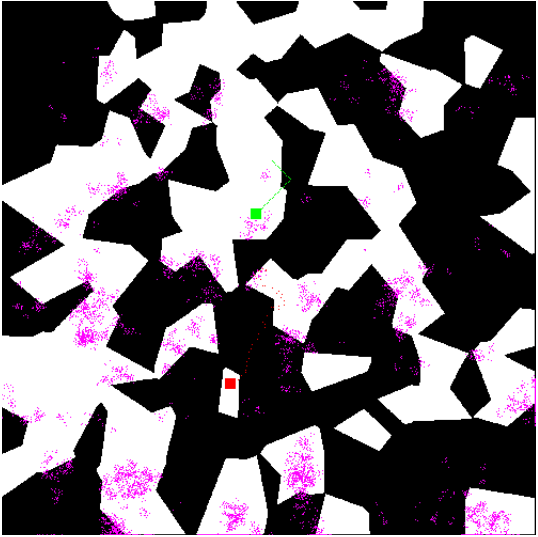
Particle filter



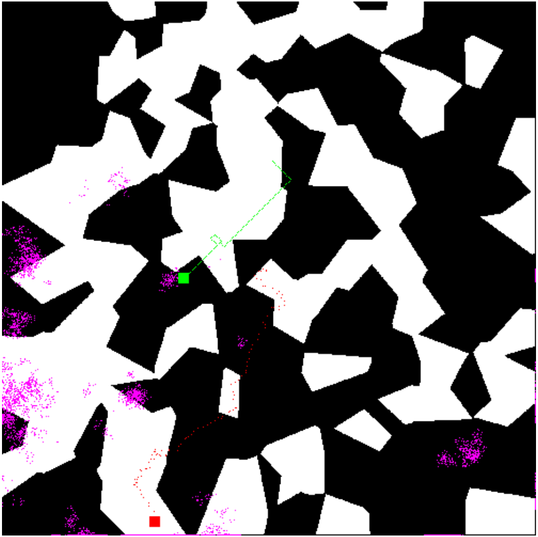
Particle filter



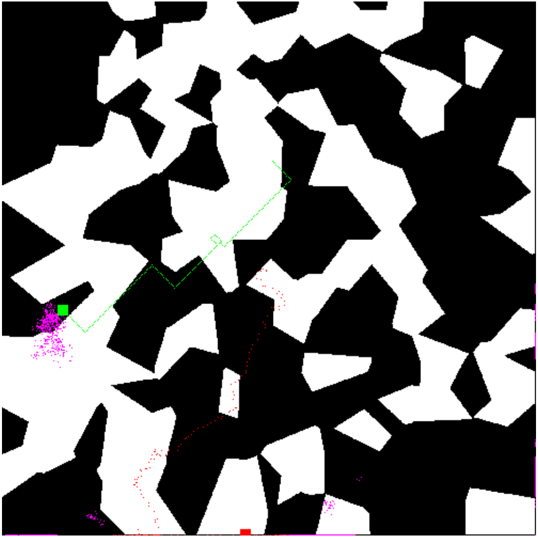
Particle filter



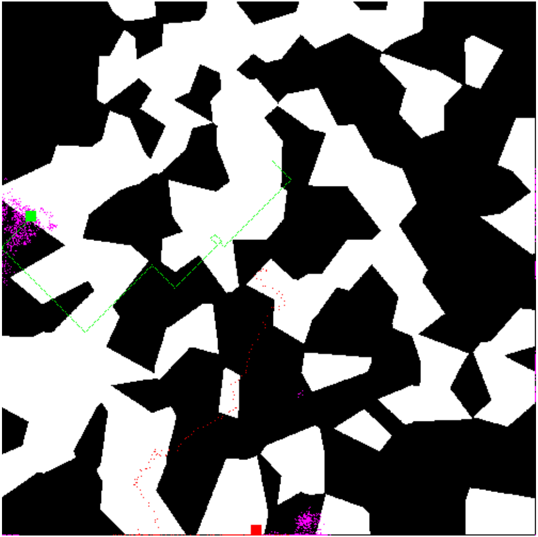
Particle filter



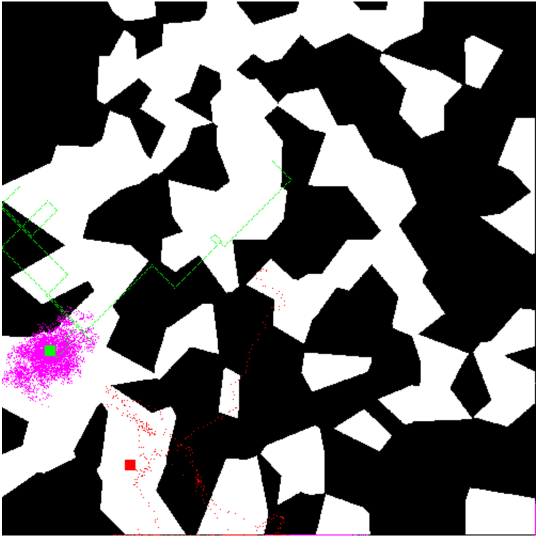
Particle filter



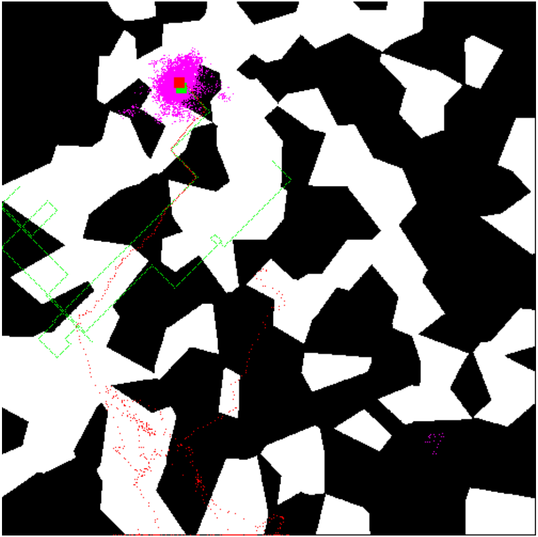
Particle filter



Particle filter



Particle filter



Q&A

https://github.com/michalnand/robotics

https://github.com/michalnand/machine_learning_new

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